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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	06192.0057
First Named Inventor or Application Identifier	Chang-Hoon LEE
Title	Liquid Crystal Display Having High Contrast Ratio
Express Mail Label No.	

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

1. [X] *Fee Transmittal Form (Form PTO-1082)
(Submit an original and a duplicate for fee processing)
2. [X] Specification [*Total Pages* 10]
(preferred arrangement set forth below)
- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R&D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claims
- Abstract of the Disclosure
3. [X] Drawing(s) *(35 USC 113)* [*Total Sheets* 2]
4. Oath or Declaration [*Total Pages* 3]
   a. [X] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 CFR 1.63(d))
   (for continuation/divisional with Box 17 completed)
   [Note Box 5 below]
   i. [ ] DELETION OF INVENTOR(S)
   Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
5. [ ] Incorporation By Reference *(useable if Box 4b is checked)*
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. [ ] Microfiche Computer Program *(Appendix)*
7. Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
   c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. [X] Assignment Papers (cover sheet & document(s))
9. [ ] 37 CFR 3.73(b) Statement *(when there is an assignee)* [X] Power of Attorney
10. [ ] English Translation Document *(if applicable)*
11. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
12. [ ] Preliminary Amendment
13. [X] Return Receipt Postcard (MPEP 503) (Two)
(should be specifically itemized)
14. [ ] *Small Entity Statement(s) [ ] Statement filed in prior application, Status still proper and desired
15. [X] Certified Copy of Priority Document(s)
(if foreign priority is claimed)
16. [ ] Other:

*NOTE FOR ITEMS 1 & 14 IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

17. **If a CONTINUING APPLICATION**, *check appropriate box and supply the requisite information:*
[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: /
Prior Application Information: Examiner: Group/Art Unit:

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December 30, 1998

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BY HAND DELIVERY

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Re: Non-Provisional Utility Patent Application
Application No.: To be Assigned; Filed: December 30, 1998
For: **Liquid Crystal Display Having High Contrast Ratio**
Inventor(s): **Chang-Hoon LEE, Jung-Uk SHIM and Kyeong-Hyeon KIM**
Our Ref: 06192.0057

Sir:

The following documents are forwarded herewith for appropriate action by the U.S. Patent and Trademark Office:

1. Utility Patent Application Transmittal Form;

2. Fee Transmittal Form 1082 (duplicate); and

3. U.S. Utility Patent Application entitled:
Liquid Crystal Display Having High Contrast Ratio

and naming as inventors:
Chang-Hoon LEE, Jung-Uk SHIM and Kyeong-Hyeon KIM

the application consisting of:

a. a specification containing:

(i) **7** pages of description prior to the claims;
(ii) **2** pages of claims (7 claims); and
(iii) a one (1) page abstract;

b. 2 sheets of drawings: (Figs. 1 – 3, inclusive);

4. a copy of the executed Combined Declaration and Power of Attorney for Patent Application;

5. Form PTO-1595 Recordation Cover Sheet and a copy of the executed Assignment to Samsung Electronics Co., Ltd., recordation of which is hereby respectfully requested;

6. our check no. 303228 for $800.00 to cover:

$760.00 filing fee for patent application;
40.00 assignment recordation fee;

7. two (2) return postcards.

It is respectfully requested that, of the two attached postcards, one be stamped with the filing date of these documents and returned to our courier, and the other, prepaid postcard, be stamped with the filing date and unofficial application number and returned as soon as possible.

Applicant hereby claims foreign priority benefits under Title 35, United States Code, § 119 to Korean Application No. 97-80199 filed on December 31, 1997.

The U.S. Patent and Trademark Office is hereby authorized to charge any fee deficiency, or credit any overpayment, to our Deposit Account No. 08-3038. A duplicate copy of this letter is enclosed.

Respectfully submitted,

Cono A. Carrano
Registration No. 39,623

Enclosures

LIQUID CRYSTAL DISPLAY HAVING HIGH CONTRAST RATIO

BACKGROUND OF THE INVENTION

(a) Field of the Invention

The present invention relates to a liquid crystal display having high contrast ratio.

(b) Description of the Related Art

A liquid crystal display (LCD) includes two substrates and a liquid crystal layer interposed therebetween. The transmittance of light is controlled by the intensity of the electric field applied to the liquid crystal layer of the LCD.

Some of the significant properties of an LCD, such as response time, contrast ratio and viewing angle are directly related to the cell gap, or the thickness of the liquid crystal layer.

Spacers are conventionally used for controlling and maintaining the cell gap of the LCD. The spacers are typically made of plastics, having elasticity such that the size of the spacers may vary according to the weight applied thereto. Accordingly, it is difficult to maintain a uniform cell gap using the plastic spacers. As a result, silica beads have become more popular as spacers since they maintain a uniform gap.

In order to make the cell gap, the spacers are usually dispersed on one of the substrates before they are assembled. Then, the substrates are sealed with a sealant, and a liquid crystal material is injected into the gap between the substrates.

Unfortunately, the alignment of the liquid crystal molecules near the spacers become disordered. In other words, the liquid crystal molecules become randomly

arranged near the spacers, but are uniformly arranged in other regions. As a result, the light leakage occurs near the spacers, thereby reducing the contrast ratio.

In particular, the LCD in normally black mode may not obtain sufficient black state due to the light leakage near the spacers, and thus the contrast ratio may be reduced.

SUMMARY OF THE INVENTION

It is an object of the present invention to reduce light leakage in the LCD.

It is another object of the present invention to increase the contrast ratio in the LCD.

These and other objects, features and advantages are provided, according to the present invention, by using spacers which align nearby liquid crystal molecules so that they are parallel to the surface of the spacers.

The LCD includes a first panel having two kinds of electrodes that are separated from each other and generate electric field by applying voltage. A second panel is spaced apart from the first panel. A liquid crystal layer is interposed between the first and the second panels and a plurality of spacers are dispersed in the liquid crystal layer. In the liquid display layer, the spacers align liquid crystal molecules near the spacers in a substantially regular manner.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of an LCD according to one embodiment of the present invention.

FIGs. 2 and 3 are plan views showing the alignment of the liquid crystal molecules near spacers according to two embodiments of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described more fully with reference to the accompanying drawings, in which preferred embodiments of the present invention are shown. In the drawings, the thickness of layers and regions are exaggerated for clarity.

FIG. 1 is a cross-sectional view of a LCD according to an embodiment of the present invention.

As shown in FIG. 1, two insulating substrates 10 and 20 are spaced apart from each other. A liquid crystal layer 30 is interposed between the substrates 10 and 20, and a plurality of spacers 40 maintaining a suitable cell gap are dispersed in the liquid crystal layer 30. A pair of polarizers, a polarizer 61 and an analyzer 62, are attached to the outer surfaces of the substrate 10 and substrate 20 respectively. The polarizing directions of the polarizer 61 and the analyzer 62 are perpendicular to each other.

Formed on the lower substrate 10 are a gate electrode 1 applied with a scanning signal . Common signals are applied to common electrodes 2. A gate insulating layer 3 is formed on the gate electrode 1 and the common electrodes 2. A semiconductor layer 4 of a material such as intrinsic amorphous silicon is formed on the gate insulating layer 3 opposite the gate electrode 1. An ohmic contact layer 51 and 52 of doped amorphous silicon is formed on the semiconductor layer 4 and includes two separate portions 51 and 52 opposite to each other with respect to the gate electrode 1. A source electrode 6 and a drain electrode 7 are formed on the respective portions 51 and 52 of the ohmic contact layer. A pixel electrode 8 to which a display signal is applied, is formed on the gate insulating layer 3. The pixel electrode 8 and the common electrodes 2 are located in a pixel region and alternately arranged to generate an

electric field. Though not shown in the figures, the drain electrode 7 is electrically connected to the pixel electrode 8. The gate electrode 1, the gate insulating layer 3, the semiconductor layer 4, the ohmic contact layer 51 and 52, the source electrode 6 and the drain electrode 7 form a thin film transistor (TFT) that receives a display signal via the source electrode 6 and transmits the display signal to the pixel electrode 8 via the drain electrode 7. Finally, a passivation layer 9 covers the TFT and the pixel electrode 8, and an alignment film (not shown) is formed on the passivation layer 9.

Formed on the upper substrate 20 are a black matrix 21 located at the position corresponding to the TFT of the lower substrate 10 and a color filter 22 located at the position corresponding to the pixel region. An alignment layer (not shown) is formed on the black matrix 21 and the color filter 22.

Now, the operation of the LCD is described.

In the absence of an electric field, the long axes of most liquid crystal molecules in the liquid crystal layer 30 are arranged in a fixed direction either substantially parallel or substantially perpendicular to the substrates 10 and 20. The incident light polarized by the polarizer 61 passes through the liquid crystal layer 30 without changing its polarization. Then, the light is blocked by the analyzer 62 to make a black state.

When an electric field is generated by applying signal voltages to the common electrode 2 and the pixel electrode 8, the liquid crystal molecules align themselves such that their long axes are either parallel or perpendicular to the field direction, while the liquid crystal molecules remain in their initial states along the alignment layer. Accordingly, the liquid crystal molecules are rearranged as follows: the liquid crystal molecules near the central region between the substrates 10 and 20, which is far from

the surfaces of the substrates 10 and 20, are either substantially parallel or substantially perpendicular to the field direction, and those near the surfaces of the substrates 10 and 20 stay in their initial states. As a result, the director of the liquid crystal layer 30 twists spirally from one substrate to the midposition between the substrates, and the incident light polarized by the polarizer 61 changes its polarization when passing through the liquid crystal layer 30. Therefore, the light, at least in part, passes through the analyzer 62 to make a white state.

FIGs. 2 and 3 are plan views showing the alignment of the liquid crystal molecules near the spacers according to two embodiments of the present invention. The spacers shown in FIG. 2 and FIG. 3 are homogeneously aligning spacers and homeotropically aligning spacers, respectively.

As shown in FIGs. 2 and 3, liquid crystal molecules 31 and 32 near spacers 41 and 42 are aligned homogeneously (FIG. 2) and homeotropically (FIG. 3) to the surfaces of the spacers 41 and 42, respectively. Then, the liquid crystal molecules 31 and 32 are arranged in a regular manner with respect to the surfaces of the spacers 41 and 42. The dotted lines represent the tangential lines of the long axes of the liquid crystal molecules.

When the homeotropically aligning spacer 42 is used as shown in FIG. 3, the size of the region where the arrangement of the liquid crystal molecules is changed due to the influence of the spacer 42 is very small compared with when using the homogeneously aligning spacer 41. It is because the aligning force of the homeotropically aligning spacer 42 is smaller than that of the homogeneously aligning spacer 43. Therefore, the light leakage due to the disordered arrangement of the liquid

crystal molecules is reduced dramatically when using the homeotropically aligning spacer 42.

Test panels were made using the spacers according to the present invention, and the luminance in the black state was measured. Then the contrast ratio CR for the LCD operating in normally black mode was calculated by the following equation:

$$CR = (\text{luminance})_{ON} / (\text{luminance})_{OFF},$$

where $(\text{luminance})_{ON}$ represents the luminance when a voltage is applied and $(\text{luminance})_{OFF}$ represents the luminance when the voltage is not applied (off state).

In this test, the size of the test panels was 15.1 inches. A bear glass panel without TFTs and wires and a color filter panel having complete elements such as color filters and a black matrix was used. Spacers of 2 g and solution of 200 ml including IPA (isopropyl alcohol) of 80ml, Me-OH of 20ml and DI (de-ionized) water of 100ml were mixed and sprayed on one of the panels using the conventional dispersing method. The spacers used in this test were "LUNAPEARL" which are manufactured by KAO, a Japanese company using a seed polymerization method, and are a copolymer including di-vinyl benzene as a primary component. The aligning tendency of the spacers is dependent on the amount of hydrophilic and hydrophobic components of the copolymer, and becomes homeotropic as the amount of the hydrophobic components increases. The number of the spacers per unit area was 120 /mm^2.

According to the test result, the luminance in the black state decreased, and the uniformity of luminance in black state increased considerably. The contrast ratio of the LCD using the conventional spacers was 169, while that for the homogeneously aligning spacers was 250, thereby realizing 47.4 % increase in the contrast ratio. When

using the homeotropically aligning spacers, the contrast ratio is 289, which indicates 70.0 % increase compared with the conventional case. As described above, the uniformity of the luminance is increased, which is believed to be caused by the present spacer's superior capability of absorbing and discharging electrostatic charges. Since the homogeneously or the homeotropically aligning spacers has a high absorption rate for ionic impurities, the amount of the electrostatic charges and thus the strength of the electric field generated by the electrostatic charges are reduced. Accordingly, the homogeneously and the homeotropically aligning spacers decrease the light leakage and the afterimage by reducing electrostatic charges.

In addition, the voltage maintaining capability of the LCD was not reduced.

According to present invention, the homogeneous or the homeotropic alignment spacers are used for the display where two field generating electrodes formed on one substrate. However, the spacers may be used in other types of LCDs, for example, twisted nematic LCD or vertically aligned twisted nematic LCD. The spacers according to the present invention are particularly useful for the LCD where the liquid crystal molecules are aligned in parallel to the substrates and operates in a normally black mode.

In the drawings and specification, there have been disclosed preferred embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

WHAT IS CLAIMED IS:

1. A liquid crystal display comprising:

a first and a second panels spaced apart from each other and having a first and a second electrode, respectively, separated from each other which generate electric field by applying voltage;

a liquid crystal layer interposed between the first and the second panels; and

a plurality of spacers dispersed in the liquid crystal layer,

wherein the spacers align liquid crystal molecules near the spacers in a substantially regular manner with respect to surfaces of the spacers.

2. The liquid crystal display of claim 1, wherein long axes of the liquid crystal molecules are aligned substantially parallel to the first and second panels.

3. The liquid crystal display of claim 2, further comprising a pair of polarizers attached to the outer surfaces of the first and the second panels, wherein polarizing directions of the polarizers are substantially perpendicular to each other.

4. The liquid crystal display of claim 3, wherein the spacers align the liquid crystal molecules near the spacers substantially parallel to surfaces of the spacers.

5. The liquid crystal display of claim 3, wherein the spacers align the liquid crystal molecules near the spacers substantially perpendicular to the surfaces of the spacers.

6. The liquid crystal display of claim 3, wherein some of the spacers align the liquid crystal molecules near the spacers substantially parallel to the surfaces of the spacers, and the remaining spacers align the liquid crystal molecules near the spacers substantially perpendicular to the surfaces of the spacers.

7. The liquid crystal display of claim 1, wherein the first panel has both the first and the second electrodes.

ABSTRACT OF THE DISCLOSURE

Alignment of the liquid crystal molecules near the spacers is controlled by using spacers which align the liquid crystal molecules parallel or perpendicular to the surfaces of the spacers. Light leakage near the spacers due to a disordered alignment of the liquid crystal molecules is reduced, thereby decreasing the luminance in black state. As a result, the contrast ratio is increased.

FIG. 1

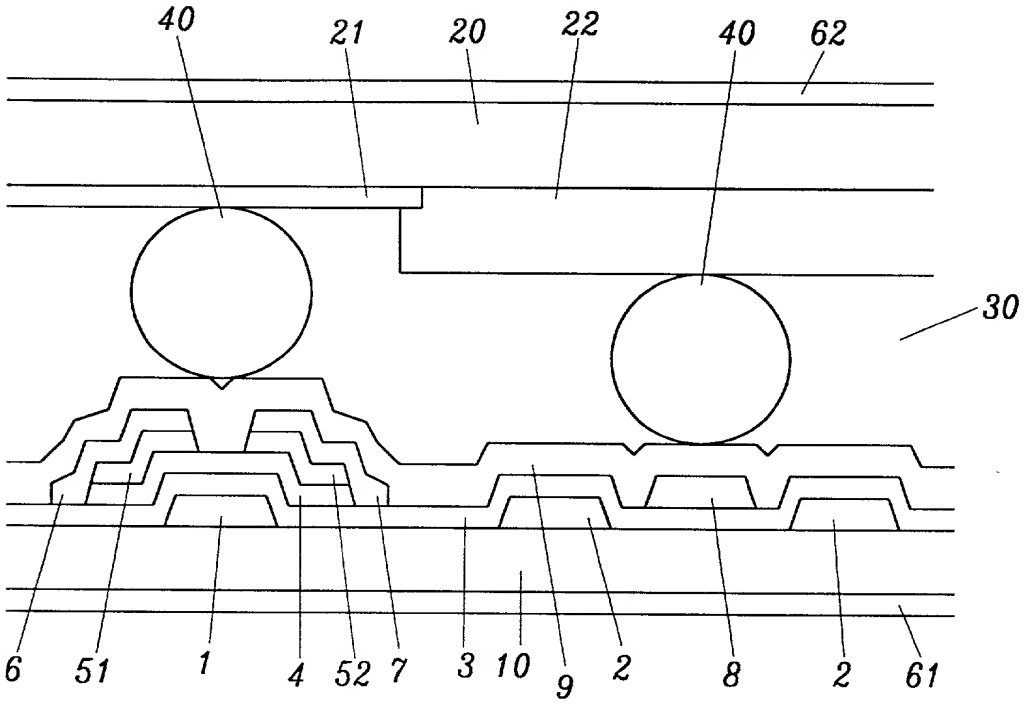


FIG. 2

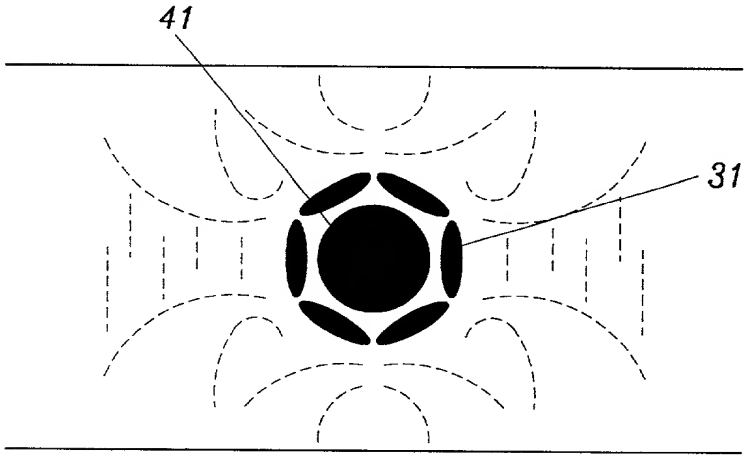
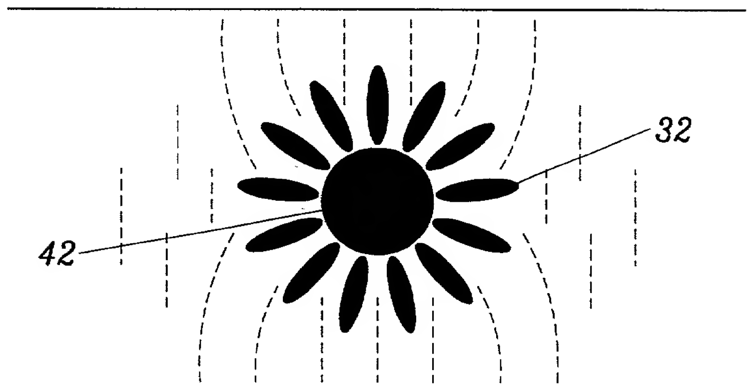


FIG.3



Combined Declaration and Power of Attorney for Patent Application

Docket Number:
06192.0057

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter that is claimed and for which a patent is sought on the invention entitled

LIQUID CRYSTAL DISPLAY HAVING HIGH CONTRAST RATIO

, the specification of which is attached hereto unless the following box is checked:

☐ was filed on ____;
as United States Application Number or PCT International Application Number ____ ; and
was amended on ____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information that is material to patentability as defined in 37 C.F.R. § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT international application, which designated at least one country other than the United States listed below, and have also identified below any foreign application for patent or inventor's certificate, or PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Claimed
			☒ Yes ☐ No
97-80199 (Application No.)	KOREA (Country)	31/12/1997 (Day/Month/Year Filed)	

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below.

(Application No.) (Filing Date)

(Application No.) (Filing Date)

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or under § 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information that is material to patentability as defined in 37 C.F.R. § 1.56 that became available between the filing date of the prior application and the national or PCT international filing date of this application.

(Application No.) (Filing Date) (Status - patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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